1936

# A study of the external morphology of a predacious stink-bug,: Apateticus cynicus (Say); Family, Pentatomidae; Order, Hemiptera-Heteroptera

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# A STUDY OF EXTERNAL MORPHOLOGY OF A PREDACIOUS STINK-BUG, Apateticus cynicus (Say); Family, Pentatomidae; Order, Hemiptera-Heteroptera

STONE - 1936

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by

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Submitted as a Thesis to the Faculty of the Graduate School
in Partial Fulfillment of the Requirement for the
Degree of Master of Science
Massachusetts State College
June 1936

C O N T E N T S

# INTRODUCTION

In the spring and summer of 1935, the writer studied the biology of Apateticus cynicus Say, of the Hemipterous family Pentatomidae. This insect was chosen for study because of its economic importance as a predator on the gypsy moth and apple tent caterpillar.

During the course of this study, the writer found that very little was known concerning this important predator. Even the life cycle of the insect in New England had not been recorded correctly. Although certain features of the Hemiptera in general have been studied, the anatomy of this insect has never been worked out. On this account, it is the purpose of the writer of this thesis to summarize in one paper the detailed external morphology of Apateticus cynicus Say.

ACKNOWLEDGMENTS

The writer is greatly indebted to Dr. Guy C. Crampton, under whose direction this work was done, for his valuable suggestions, criticisms and assistance throughout the progress of the work. To Dr. C. P. Alexander the writer wishes to express his thanks for his continued encouragement and criticism of the work. Thanks are also due to Dr. H. L. Sweetman, under whose direction the biology of the insect was studied; and to Mr. A. F. Burgess for supplying the writer with numerous specimens of Apateticus cynicus Say.

## Head

The prominent, lateral compound eyes, and the deep anterior clypeal-jugal clefts, are the outstanding visible characteristics of the dorsally flattened quadrangular head capsule. In the ventral portion, the greatly developed gular region has thrown forward the whole of the ventral lateral parts of the head, causing the formerly anterior surface to become dorsal, while the mouthparts are directed downward. When the head capsule, which is similar in both sexes, is viewed from above or below, the absence of sutures, due to the solid fusion of the sclerites, is very apparent; therefore, only a description of the general regions of the head will be taken up in this paper.

The occipital arch (occ) (Fig. 1), which is not differentiated anteriorly by a suture, lies at the back of the cranium behind the ocelli (oc) and is demarked posteriorly by the postoccipital suture (pos). There is no visible suture between the dorsal and lateral parts of the arch, but the terms occiput and postgenae (pge), respectively, may be applied to the dorsal and lateral areas posterior to the genae (ge).

The postoccipital suture (pos) surrounds the occipital foramen (ocf) dorsally and laterally, and is limited ventrally by the posterior arms of the tentorium.

The postocciput (poc) (Fig. 1) is the narrow posterior rim of the head behind the occipital arch, and is demarked from it by the postoccipital suture. The postocciput is partly strengthened by the infolding of its posterior edge.

The neck membrane, which is devoid of sclerites, is attached to the postocciput, and in normal position encircles the posterior margin of the head. This membrane, which is attached to the anterior rim of the prothorax, permits the head to be protruded, or to be retracted into the socket formed for its reception in the prothorax.

The area of the clypeus, or tylus according to Snodgrass, is marked by the origins of the dialator muscles of the sucking pump, which, in this case, extend backward between the ocelli on the dorsal surface of the head. The clypeus (Fig. 1) is divided into the anteclypeal (aclp) and postclypeal (clp) regions.

The anteclypeal region is bounded by deep clefts and forms a separate triangular tube-like projection over the anterior part of the head capsule. The anteclypeal tube may be divided into an anterior and posterior region by a line drawn laterally across the distal end of the inner clypeal lines. Internally, and posterior to this imaginary line, the sucking pump plunger is raised and lowered by muscles extending perpendicularly between the membranous plunger and the clypeal region. The external manifestations of the muscles are the inner clypeal lines. Anterior to the distal end of the inner anteclypeal lines, a sheath is formed by an infolding of the ventral membranous region of the anteclypeus to accommodate the converging mandibular and maxillary setae. This concave tube or sheath continues to the end of the labrum. The anteclypeus is held firmly in place by two narrow lateral plates, which fit into grooves running along the under side of the dorsal chitinous surface of the frons.

The postclypeal region (Fig. 1) is not demarked by a visible suture, and is contained within the region between the anteclypeus and the ocelli.

The genae, or checks(ge), (Fig. 2) lie on each side of the head below and behind the compound eyes (e) and are demarked ventrally by the greatly extended gular sutures (gus). The postgenae (pge) are the lower continuations of the occipital arch. The gular region (gu) comprises the median part of the lower surface of the head behind the labrum (lbr) and is demarked from the genae by the gular sutures.

The frons, juga, or frontal ridges (fe),(Figs. 1, 2, 4) which are anterior dorsal continuations of the dorsal surface of the head, are greatly developed and conspicuous. The outer lateral margins are broadly rounded and slightly overlap the anterior sides of the clypeus. The inner surfaces below the chitinous outer cuticula are grooved to receive the lateral projections of the clypeus.

The bucculae (bu) (Figs. 2, 4) are the small cheeks, or distended areas of the ventral part of the head, on either side of the labium. They are slightly raised anteriorly and converge behind the labium. Morphologically they are formed by an infolding of the body wall in the formation of the basal segment of the rostrum.

The mouthparts are composed of the maxillary and mandibular setae, the labrum, and the labium.

The labium (Fig. 4) forms the rostrum, or beak (lab), which is a prominent tubular four-segmented structure. It is joined, directly behind the labrum, to the anterior ventral part of the head, and reaches nearly to the hind coxae in its normal concealed position beneath the body. A membrane (Fig. 2) extending between the basal segment of the labium and the posterior part of the bucculae allows the forward movement of the rostrum. The basal segment of the beak (Fig. 4) is large, well-developed, and stout, and is only slightly buried between the bucculae. The second segment is more slender and twice as long as wide. The third and last segments are slightly shorter than the first two and are nearly equal in length. The fourth segment is provided with sensory hairs at its tip.

The dorsal surface of the labium (Figs. 3, 4, 7) is deeply grooved to form a trough to accommodate the labrum and the mandibular and maxillary setae. The labium is controlled by the protractor and retractor muscles. The protractor muscles, which are attached to the base of the tentorium, extend the length of the basal segment on either side of the dorsal groove. The retractor muscles are attached to the ventral side of the tentorium and extend along the posterior part of the rostrum.

The labrum (lbr) (Figs. 2, 3, 4) is a narrow elongate triangular structure that rests over the proximal portion of the labial groove, and is continuous with the anterior ventral part of the clypeus. A short membrane lies at the anterior basal portion of the labrum, and allows the freedom of forward movement of the structure from its normal concealed position beneath the head. The labrum extends distally through the first, and part way into the second, labial segment. Its dorsal surface is convex, while the ventral surface is flat. The median part of the ventral surface (Fig. 3) is bent under to form a sort of trough, which is continuous with the trough or sheath along the ventral surface of the anteclypeus, and in which are contained the setae.

The two maxillary (mx), and two mandibular (md), setae arise as separate setae from the walls of the bristle pouches in the posterior part of the head. They converge, slightly distad to the tips of the inner anteclypeal lines. At this point they come in contact with the food tube of the pharynx and the salivary tube from the salivary pump. The setae (Figs. 2, 3, 4) then continue in a trough formed by the infolding of the ventral membranous region of the anteclypeus, and distally, by the infolding of the ventral median region of the labrum. The setae (Fig. 7) are then enclosed in a sheath of the labium, which is formed by the meeting of the edges of the dorsal groove.

The setae (Fig. 5) are held together by interlocking grooves and ridges. The mandibular setae inclose the maxillary pair, and function as a sheath and guide. The interlocking maxillary setae are grooved along their inner opposed sides and form, when they converge, two parallel channels. These channels become the food duct (p) and salivary duct (n), and lie dorsally and ventrally, respectively.

The tips of the mandibular setae are barbed, in order to hold the setae in place while piercing the prey. The tips of the maxillary setae are very sharp.

The setae are exposed primarily by the forward swing of the beak, and secondarily by the bending of the first and second segments, which thus allows the stylets to be guided at their basal end by the trough of the labrum. The piercing of the stylets is accomplished chiefly by the mandibular setae. These advance alternately into the host tissues. First one mandibular seta advances, then the other advances to meet the tip of the first, and as a third movement, the two maxillary setae push forward into the space left behind the mandibular setae. These movements are controlled by the protractor and retractor muscles.

The slender antennae (ant) (Figs. 1, 2, 4, 6) are nearly half as long as the body. They are composed of seven segments, of which the fourth and sixth are ring "joints" (r) or reduced segments, and therefore cause the antennae to appear to be composed of only five segments. The antennae are of a brick red color, except for the ring joints, which are paler. The entire surface of the antennae is thickly covered with minute sensory hairs.

In changing from the last nymphal stage to the adult, the number of antennal segments increases from the apparent four to five. This is accomplished by the division of the elongated second segment of the nymphal stage into segments two and three of the adult.

The first segment or scape (sa) (Fig. 6) is small, thick, and with an elongate base or bulb (bc). The bulb (Figs. 2, 4) fits into an antennal socket which is situated in front and below the compound eyes, and is bordered by the antennal sclerite. This bulb and socket joint allows greater freedom of movement of the antennae. Of the remaining normal segments, which are longer and more slender than the first, the second is the longest, the fifth the shortest, and the third and fourth are subequal. The terminal segment is slightly flattened dorsally and ventrally, and is convex laterally.

The majority of the muscles from the antennae are attached to the dorsal part of the head mesiad to the compound eyes, and, on the surface, produce a muscle scar (ms) (Fig. 1) which is slightly sunken posteriorly.

The prominent red compound eyes (e) (Figs. 1, 2, 4) are borne on lateral protuberances of the head. The ocular sutures are the grooves which border the compound eyes.

The bright red ocelli (oc) (Fig. 1) are two in number, and are placed far apart in a transverse line slightly behind the compound eyes.

## Prothorax

Although the prothorax of *Apateticus* is very conspicuous from above (Fig. 16), only a narrow restricted anterior region of the tergum of the segment bears muscles. The front margin of the prothorax is folded dorsally and ventrally to form a collar-like rim (cr), which serves as a shelter into which the posterior part of the head retracts. Continuous with the inner part of the rim is the neck membrane. This membrane is devoid of sclerites and is connected with the post-occiput.

The tergum is thickly marked with small reddish punctures and is twice as long as wide across the humeri (hm). The front margin (Fig. 16) is coarsely crenate, and the tergum is produced laterally into the flattened triangular subspinose humeri. The front half of the tergum, behind the frontal angles, has a triangular, green, smooth area (ma) on each side of the middle. These areas indicate the position of the dorsal attachments of the large leg muscles. Posterior to these muscle scars, the tergum is prolonged into a greatly elongated flap (pf). Malouf, 1932, states that "this flap should not be considered as a reduplication in the sense of the posterior tergal region reduplicating, but rather should be considered as a flap-like evagination of the tergal region." The under fold of the flap, whether it is a reduplication or a flap-like evagination of the tergal region, is continuous with the dorsal region of the flap, and extends anterior to the prothoracic-mesothoracic conjunctiva (cn), which lies laterally across the tergum, directly behind the triangular muscle scars.

The two layers of the tergal flap are held in place by small peg-like chitinous projections from the center of the under surfaces of each fuscous puncture. When viewed laterally, these chitinous pegs look like rivets holding the two layers apart. These same peg-like projections are lengthened when the surfaces become further apart, as in the humeri.

Pleuron.

The pleuron (Fig. 17) is continuous with the sternum and is not detached from the tergum, as is the case in the mesothorax and metathorax. Anteriorly the pleuron doubles back on itself to form a part of the rim, or shelf, into which the head retracts. The pleuron is divided laterally by the coxal cleft (c) into the episternum (eps) and the epimeron (em). The episternum and epimeron evaginate ventrally to form the double-walled flaps that encircle the coxa. On either side of the coxal cleft the episternum and epimeron bulge to allow more room for the leg muscles. The extremities of this bulge are marked internally by the anterior and posterior prothoracic conjunctiva. The prothoracic-mesothoracic conjunctive (cn) (Figs. 16, 17) crosses the tergum dorsally behind the two triangular muscle scars (ms) and is continuous with the pleuron at the posterior end of the dorsal convex ridge (cv). It continues about the back of the coxal bulge to form a bridge that lies behind the furcae and between the pleural-epimera. Another membranous ridge, or wall (in) is attached between the dorsal convex ridge and the tergum. Thus the sides and back of the prothorax do not serve for muscle attachments.

Sternum.

The sternum of the prothorax (Fig. 17) is the small ventral region, between and anterior to the coxal cavities (cc). It is a thin, sclerotized area, which is indistinguishably fused with the coxal cavities, and with the pleuron, by the precoxal bridge.

The furcae (fu) protrude internally in the region below the posterior portion of the coxa, and are continuous with both the ventral lateral extension of the epimeron and the intersegmental conjunctiva. They are used for muscle attachments. Externally the furcae are evidenced by their invaginations called furcalpits (fp). The anterior region, the basisternum (bs), is elevated mesially.

Legs

A description of a fore leg (Fig. 11) will suffice for all of the legs, since it is practically the same as the other legs, except for the fact that it is slightly smaller. It is composed of five divisions: coxa (cx), trochanter or fulcrum (tr), femur (fe), tibia (ti), and tarsus (ta).

The trochantin (trn) (Fig. 10), which is not considered a part of the leg, is attached inside the coxal cavity near the basal end of the pleural suture. It lies along the anterior side of the basal half of the coxa, and its tip forms a pivotal point for the coxa.

The freely movable coxa, or basal segment of the leg (Fig. 17), lies almost entirely within the coxal cavity. It is attached basally to the coxal process of the pleuron, at the base of the pleural suture. Two distal ridges of the coxa, namely, the anterior and posterior trochantifers, form a dicondylic articulation with the condyles of the trochanter.

The trochanter (Figs. 11, 17) is a short curved segment. Although it articulates freely with the coxa by a hinge-like joint, it is more or less fused, or fixed, to the base of the femur.

The femur (Fig. 11) is the thickest and longest segment, and contains the majority of the leg muscles. It does not articulate with the trochanter, as mentioned above. The femur articulates with the tibia by a dicondylic joint. This is formed by the anterior and posterior tibia condyles, which are two small peg-like lateral projections of the tibia which fit into the tibiafers, or processes on the sides of the distal end of the femur.

The tibia (Fig. 11) is long and slender, and only a little shorter than the femur. The proximal end of the tibia is curved, and thus allows the tibia to be flexed close to the flat distal ventral surface of the femur. Slightly distad to the middle of the inner side of the tibia, is a row of about fifteen hairs. These are found only on the prothoracic legs, and are used as an antennae cleaner.

The three segments of the tarsus (Fig. 11) may be referred to as the tarsomeres (ts). The basal tarsomere is preferably called the basitarsus (bt), although the segment is invariably referred to by entomologists as the metatarsus. The basitarsus articulates with the tibia by a dicondylic joint. This joint is formed by the anterior and posterior tarsocondyles, which are received into corresponding anterior and posterior tarsofers, or tarsus-bearing processes of the tibia. The basitarsus is ventrally thickly covered with hairs. The upperside of the basitarsus, and the whole of the second and third tarsal segments, are completely covered with fewer, but longer, hairs. The third, or distal, tarsomere may be termed the distitarsus (dt).

The pretarsus (ptar) (Figs. 11, 15) includes the terminal parts of the leg distal to the distitarsus. The chitinous plate, called the unguitractor (ut), is continuous with the empodium (emp), which bears a parempodium (pem) on each side of two lateral protuberances. A membranous region stretches above the unguitractor and empodium, and between the base of of the ungues (un) or claws. The ungues have large chitinous bases. The basipulvillus, or chitinous base of the pad-like pulvillus (pv), is attached at the base of the ungues, and its appearance suggests that the pulvilli were once a part of the claws. According to Crampton (1923), and Holway (1933), this condition possibly indicates a way in which sub-ungual pads may be developed and split from the claws.

## Mesothorax

The prescutum (psc), and scutum (sc) of the mesothorax (Fig. 14) are completely covered by the posterior flap of the prothoracic tergum. The scutellum (sct), however, is very prominent from above and extends posteriorly to the fifth abdominal segment.

The mesothoracic spiracles lie within the intersegmented membrane (Fig. 8) between the prothorax and mesothorax, and are obscured from view by the ventral part of the prothoracic epimeron. The precosta (pct), or pretergite, is very prominent (Figs. 9, 14). It is wide mesially and tapers laterally until it disappears anterior to the scutal region. The first phragma (ph) (Fig. 9) is large and projects perpendicularly into the thoracic cavity. Medianly it is traversed by a continuation of the median groove (m) of the region of the prescutum.

The prescutum (Fig. 14) is generally considered to be the region that is contained within the parapsidial furrows (par). Some entomologists, however, interpret it as the small narrow anterior area (Fig. 9) which is bounded by the precosta, prealar bridge (prb), and the precostal suture.

Lying both laterad and slightly posterior to the parapsidial furrows (Fig. 14) is the region of the scutum. This area is marked off by muscle attachments which are represented in Figure 14 by dotted lines. Extremely laterad are the vectis dorsalis anterior (va) and vectis dorsalis posterior (vp) (Malouf, 1933), which are processes that act as levers to the tergo-sternal muscles. Between these processes and the major papapsidies, according to Malouf, in Nezara there are three well-marked depressions. In Apateticus there are, apparently, two irregular areas caused by two large muscle attachments.

Posterior to the transverse line (k) (Fig. 14), which is the extremity of the scutum, lies the extremely elongate scutellum (sct), that reaches to the fifth abdominal segment. Extending along the lateral edges of the scutellum is a ridge called the frenum (fre). The postscutellum is dorsally fused with the epimeron and forms the postalar bridge.

The sterno-pleural region.

The sternum and pleuron are solidly fused (Fig. 18). The pleuron may be divided into the episternum and epimeron by an imaginary line drawn from the coxal articulation (o) in the coxal cleft, to the dorsal reappearance of the pleural suture (pls). The pleural wing process (pp) (Fig. 8) is the dorsal extremity of the pleural ridge, and fits into a concavity formed by the second axillary (2ax) of the fore wing. A prominent ridge (rd) (Figs. 8, 18) runs distally from the median anterior part of the episternum toward the pleural wing process. The region anterior to this ridge, the anterior basalare (aba), has become solidly fused to the episternum, and lies normally under the epimeron of the prothorax. The posterior basalare (pba) (Figs. 8, 9) has also become fused to the dorsal part of the epimeron.

Medially in the anterior part of the basisternum (Fig. 18) a ridge (rg) demarks a circle anteriorly and runs posteriorly to form a large basisternal flap that ends between the coxa. These posteriorly directed ridges become approximated on the ventro-medial line. Posterior to the basisternum is the sternal intersegmental ridge, or post-coxal ridge (pclr), which divides the mesothorax from the metathorax.

The sternal furcae (Fig. 18) arise slightly posterior to the basisternum from the lateral part of the postcoxal ridge. The position of the furcae is indicated externally by depressions slightly mesad of the coxal cavities. The coxal cavities (cc) lie at the rear of the segment, and the coxae are slightly convergent. The cavities are formed anteriorly by the inner surfaces of the epimeron, episternum, and sternum, and posteriorly by the anterior margin of the metasternum and metaspisternum.

## Fore Wings

The interpretation of the veins of the fore wing has been worked out by Tanaka, 1926, but his work has not been available during the preparation of this paper. The following account of the wing venation is according to Handlirsch (1902) and Tillyard (1926).

The fore wing (Fig. 12) is typically Heteropterous. It is divided into a basal coriaceous portion, called the corium (co), and a thinner membranous distal part called the membrane (mem). The clavus (cl) or anal area, is also hardened, and is separated from the corium by the claval suture (cls). The distal membranous area of the hemielytron contains branches of the main veins, which have become detached by the sclerotization of the basal part of the wing.

The subcosta (Sc) in most of the specimens studied, faded out near the margin, but in one case, this vein persisted as shown in the Figure. The radius (R) is well developed basally, but becomes less distinct distally. $R_1$ is missing. Handlirsch finds that the missing $R_1$ is clearly preserved in the family Dunstaniidae, a fossil Hemipteron of the upper Triassic.

Media (M) runs closely parallel to radius for two-thirds its length, and then curves posteriorly and distally. Only one separate case was found, among the wings studied, in which media extends to the membranous portion of the wing, while in the majority of cases it fades out shortly after curving posteriorly.

Cubitus (Cu) extends well in front of the claval area, and curves forward distally. $Cu_2$ is absent. According to Tillyard, $Cu_2$ is probably lost in the claval suture. In the claval area, the first anal, 1A, is very strong and lies close to the claval suture. The second anal vein, 2 A, is less distinct. Both 1A and 2A bear small enlargements at their distal extremities.

Comstock and Needham consider the most anterior trachea in the nymphal wing to be C, the second Sc, the third R, and the fourth M, and consider that the fifth trachea laying posterior to the claval suture is Cu. The discovery by Handlirsch, which was mentioned above, shows that this interpretation which places Cu in the claval area, is untenable.

Axiliaries of the fore wing.

The humeral or basicostal plate (hp) (Fig. 14) lies at the base of the costa. It is connected to the dorsal part of the mesothoracic pleuron by a thick membrane. The small, inconspicuous, first axillary sclerite (ix) (Fig. 14) lies somewhat under the dorsal surface of the tergum. It articulates medianly with the anterior notal wing process (anp) of the tergum, and the tergal margin. Laterally it articulates with the second axillary (2x), while the anterior end is associated with the base of the subcostal vein. The second axillary is much larger and more prominent than the first axillary, and is visible both dorsally (Fig. 14) and ventrally (Fig. 8). Its anterior end is flexibly attached to the greatly enlarged base of the radial vein. Ventrally it forms a concavity (Fig. 8) that receives the pleural wing process (pp). The median axillaries are fused together and lie between the enlarged base of the radius and the claval area. The third axillary (3x) is elongated and articulates basally with the posterior notal wing process of the tergum. Distally (Fig. 8) it is flexibly attached to the ventral side of the claval area, and is then curved anteriorly to be associated with the second axillary. According to the description of its function in Nezara, by Malouf (1933), it serves to elevate the anal region of the wing when being flexed upon the thorax.

Metathorax

The tergum (Fig. 14) is reduced to a small region and its median portion is concealed under the mesoscutellum. The pretergite is indistinguishably fused with the posterior phragma of the mesothorax. The scutum ($sc_3$) and scutellum

($sct_3$) appear laterally from under the mesoscutellum (Fig.14) where the metascutellum is continued into the axillary cord (axc) of the hind wing. The postscutellum ($psl_3$) is fused to the episternum. The third phragma is only fairly well developed laterally.

Sterno-pleural region.

The metasternum (Fig. 19) is not clearly separated from the metepisternum and is very similar to the sternum of the mesothorax. The episternum is extremely large. It has a continuous episternal flap which conceals the epimeron. Laterally in the episternum a ridge (rd) marks off an anterior portion which is concealed under the mesothoracic epimeron. Slightly posterior to this ridge is the scent gland cleft (sg) which opens medianly. The coxal cavity is formed by the sternum, episternum, epimeron, and by an anterior median fold of the first abdominal segment.

The furcae lie in the lateral anterior part of the basisternum, and their position is not indicated by a depression, as in the mesothorax. The metathoracic spiracles (Fig. 8) lie within the folds between the meso-epimeron and metaepisternum.

## Hind Wings

The membranous, distinctly veined, hind wings lie folded beneath the front wings when at rest, and are shorter and wider than the latter. Although the costa (Figs. 8, 13, 14) is attached to the subcosta and radius, it diverges at the base of the wing to become marginal. Along the margin it fades out and reappears only for a short distance at the center margin of the wing. The subcosta and radius have combined to form one vein that divides distally.

Hoke figures the nymph of Apateticus sp. in which the subcosta and radius run parallel to one another. The median vein lies slightly posterior to the combined subcosta and radius, and curves distally. The nomenclature of the median veins is taken from Hoke (1926) who considers that the basal ends of $M_3$ and $M_4$ are connected to form a U-shaped vein. According to Hoke, the two veins that are fused basally and lie posterior to $M_4$ and cubitus and first anal. The second anal vein, which is strong basally, is distinctly attached to the third axillary, and lies midway between the first anal and the posterior margin of the wing. The three folds of the wing lie between $M_{1+2}$ and $M_3$, $M_4$ and Cu, and 1A and 2A.

Axillaries of the hind wing.

In the hind wing (Fig. 14), the small first axillary sclerite (1x) is connected by a membrane to the anterior lateral extremity of the metatergum, and is adjacent dorsally to the second axillary sclerite (2x). The second axillary forms the principal hinge of the wing, and is connected anteriorly with the base of the radius. The ventral part of the second axillary articulates with the pleural wing process. The third axillary (Figs. 8, 14) is involved in the flexing of the wing. The anterior arm articulates with the second axillary. The distal arm is associated with the base of the anal vein, while the posterior arm is attached to the metasternum.

Abdomen

The abdomen of both male and female is composed of ten segments, and possibly eleven, if the anal opening (ao) (Figs. 21, 23) which forms a chitinous rim at the distal end of a membranous prolonged tube of the tenth segment is considered a segment. The pleural areas, or connexiva (con) (Fig. 25) lie on either side of the dorsally flat tergites (t). They extend to the lateral edges of the sternites (st) and form a trough in which the wings lie when at rest. The ventral area of the abdomen is convex.

The spiracles (sp), which are located near the dorsal edge of the sternum, are present on the first eight segments of both sexes. The first abdominal spiracles are nearly obliterated. They lie (Fig. 25) within the dorsal membranous portion of the segment and are marked by a dark oval of chitin. The reduced eighth abdominal spiracles of the female (Figs. 20, 21) and male (Fig. 27) lie in the ventrally directed tergal plate, and in the anterior lateral part of the eighth segmental sheath.

The first three abdominal segments (Figs. 24, 25) are narrower than the following four segments. The tergite of the first segment is closely associated with the post-scutellum or postnotum of the metathorax, and is membranous anteriorly and sclerotized posteriorly. The sternite of the first segment is represented by a very small membrane. Only the anterior portion of the second abdominal tergum is sclerotized, while the posterior part is membranous. The membranous portion doubles back part way under the sclerotized portion, where it is attached to the third tergite. A part of the anterior sclerotized portion of the tergite of the second abdominal segment, therefore, overlaps part of the third tergite, while the membranous portion of the second tergite allows considerable freedom between these two segments. The attachment between the second and third tergite is shown (Fig. 25) by a dotted line. The sternite of the second segment (Fig. 24) is wide laterally, but decreases in size mesially to form the posterior portion of the metathoracic coxal cavity. The third abdominal tergite is reduced mesially. The third segment gives rise to a ventral median spur (va) (Fig. 24) which extends anteriorly to the middle of the mesothoracic coxa.

Male genitalia.

The segments in the abdomen lying posterior to the seventh segment are greatly modified, and are associated with the genitalia. These terminal segments do not show distinct tergites and sternites, and are normally retracted within the preceding segments. The eighth segment (Fig. 27) is visible only during copulation and is greatly reduced in size. The sternite is enlarged and sclerotized while the tergite or dorsal surface is membranous. The whole segment is thus modified in the form of a sheath (Fig. 27) in order to accommodate the ninth segment, which fits closely within it when retracted. The eighth and ninth segments are connected by an elongated intersegmental membrane, which allows great mobility for the genital segment.

The ninth, or genital segment, is highly modified, and when retracted within the eighth segment, there is visible only a very small portion of its surface. The ventral region of the ninth segment extends distad to the dorso-lateral region, and forms laterally rounded tips, which extend slightly dorsad to the region of the connexivum. A shallow cup-like depression is thus formed, which opens caudad and somewhat ventrad. The genital structures lie within this depression.

A transverse ridge, which is the inferior ridge (inr) (Figs. 22, 23, 27) is cephalad to the ventral border of the genital cup (bgs). It projects slightly caudad and is very easily distinguished by two groups of long hairs which curl caudo-mesad to intermingle and nearly conceal the mesal portion of the ridge. In Figures 22 and 23 only enough of these hairs were drawn to show that their tips intermingle.

The penis or aedeagus (aed) (Fig. 26) is attached by its ventral connectives (vc) to the floor of the genital cup beneath the inferior ridge. The aedeagus is invisible (Fig. 22) when the genital structures are at rest, because the proctiger (prt) or tenth segment lies above it.

The structure of the aedeagus varies among the Pentatomidae. The basal plate (bp) (Fig. 26) is practically the same as that of Apateticus bracteatus, as dhown by Malouf (1931), an nearly surrounds the base of the penial theca (pth). The two ventral connectives of the basal plate are sclerotic structures which, as stated before, run ventrad and caudad to merge in the floor of the genital cup. The dorsal connectives (dc) arise from the caudo-dorsal sides of the basal plate and run cephalo-dorsad from it. Distally the dorsal connectives are connected by chitinous threads with the central region of the claspers. These ventral and dorsal connectives control, to a large degree, the extension and retraction of the aedeagus. The penial theca, or aedeagus proper, consists of a basal articulation with the basal plate, and then continues distally as a more sclerotized cylindrical structure. Within the penial theca is enclosed the seminal reservoir, from which arises the ejaculatory duct (ed). Distally the penial theca (Fig. 26) encloses the lateral penial lobes (lpl), and the median penial lobes (mpl), while the ejaculatory duct protrudes between the median penial lobes.

The two, hining, smooth claspers (cps), parameres or harpagones (Figs. 22, 23) are situated on either side of the aedeagus within the genital cup. They are divided near their bases into two finger-like processes. The dorsal process, "superior lateral process" of Sharp (1904), is short, comparatively broad and rather flat when compared to the same process of Apateticus bracteatus, which is "peculiarly twisted from the base, narrow, and more acutely pointed." The ventral process, "lateral appenddge" of Sharp, lies caudad to that of the dorsal process. The ventral process is short and extends straight forward, while in Apateticus bracteatus the appendage is very long and reaches the outer edge of the cavity. According to Baker (1931), the function of the claspers is two-fold, - "to assist in separating the genital sclerites of the female, and to assist as clasping organs during copulation."

Directly cephalad to the deflexed portion of the claspers, within the genital cup (Figs. 22, 23) (hypandrial valves, Crampton, 1922), lie the prominent sclerotized ear-like structures or genital plates (gtp). According to Baker they are formed from the lateral walls of the ninth sternite and are free except where their midectal margin margin merges into the inner surface of the genital cup.

The proctiger (prt), or rectal cauda of Sharp, (Figs. 22, 23), or the much reduced tenth segment, also lies within the genital cup. It extends laterally across the median dorsal region of the ninth segment and vertically to the thickly-haired inferior ridge. It is connected with the ninth segment by a small hinge-like intersegmental membrane, which is attached to the dorsal inner surface of the genital cup. The tenth segment is movable dorso-ventrally and functions as a cover that protects the aedeagus. The outer surface of the tenth segment is highly sclerotized while the ventral portion is membranous. The anal opening (ao) is situated along the ventral portion of the proctiger. A membranous tube extruded from the anal opening allows the feces to be deposited beyond the genital cup. The distal end of the membranous tube is distinguished by a slightly thickened rim, which is surrounded by a row of fine hairs.

Female genitalia.

The eighth and ninth segments of the abdomen comprise the genital segments of the female (Figs. 20, 21). The posterior portion of the seventh sternite is modified to form a lobe (a) that functions as a cover over the delicate parts of the genital chamber. In *Anasa tristis*, this posterior ventral portion of the seventh segment is divided along the median line to form two lobes that overlap the first valvifers, and in this latter case, these lobes are termed the first pair of subgenital plates. In *Apateticus cynicus*, the first valvifers (1 vfl) laterally overlap the fused lobes of the seventh segment. When the lobe is raised, as in Figure 21, the first valvifers are also elevated and allow the genital chamber, which lies below the seventh segmental lobe, to come into view. The first valvifers are triangular, sclerotized plates, lying on either side of, and slightly overlapping, the edges of the ventral lobe of the seventh segment. The ventral part of the eighth segment is entirely membranous. The tergite is dorsally a flat sclerotized region that extends laterally and ventrally to form the triangular plates (8t), which bear the reduced spiracles of the segment. The first valvulae (1 vl)

(Fig. 21) are represented by two broad membranous lobes. These membranous lobes lie beneath the lobe of the seventh segment and completely cover the genital chamber. Basally these membranous lobes are attached to one another, but distally separate into broadly rounded flaps. In Anasa tristis, the second valvulae are united with each other except at their distal ends. In Apateticus, the second valvulae (2 vl) (Figs. 21, 21) are completely united to form an external chitinous sclerite, which is fused dorsally to the tenth segment, and laterally to the bases of the ninth tergites. The second valvifers are membranous and are fused with the second valvulae. The ninth tergite (9t) is produced laterally into two sclerotized flaps, which lie mesad of the eighth tergite, while dorsally the ninth tergite is membranous except for the sclerotized ridge at the base of the tenth segment. Along their ventral edges, the sclerotized flaps of the ninth tergite are associated with the sclerite formed by the fused distal ends of the second valvulae. These lobes overlap the lateral edges of the tenth segment. Externally the tenth segment is a small sclerotized plate lying distad, and fused to the plate of the second valvulae, while its unexposed surface is membranous. The continuation to the tenth segment forms a membranous tube, which is similar to that described in the male, and when at rest is likewise folded within the segment.

## Literature Cited

Baker, A. D.

1926 Some remarks on the feeding process of the Pentatomidae (Hemiptera-Heteroptera). 19th Ann. Rep. Quebec Soc. Prot. Plants: 24-34.

1931 A study of the male genitalia of Canadian species of Pentatomidae. Can. Jour. Res. 4: 148-220.

Balfour-Browne, Frank

1922 The text-book of practical entomology. Longmans, Green & Co., New York : 118-126.

Blatchley, W. S.

1926 Heteroptera of eastern North America. Nature Pub. Co., Indianapolis, Ind.

Brindley, M. D. H.

1930 On the metasternal scent glands of certain Heteroptera. Trans. Ent. Soc. London, 78: 199-207.

1933 The development of the thoracic stink glands in Heteroptera. Proc. Roy. Ent. Soc. London, 8: 1-12.

1934 The metasternum and pleuron of Heteroptera. Trans. Ent. Soc. London, 82: 43-50.

Comstock, J. H.

1918 The wings of insects. Comstock Pub. Co., Ithaca, N. Y. 292-294.

Crampton, G. C.

1914 Notes on the thoracic sclerites of winged insects. Ent. News 25: 15-25.

1917 A phylogenetic study of the terminal abdominal segments and appendages in some female Apterygotan qnd lower Pterygotan insects. Jour. N. Y. Ent. Soc., 25: 225-236.

Grampton, G. C. (Cont.)

1918 A phylogenetic study of the terga and wing bases in Embiids, Plecoptera, Dermaptera, and Coleoptera. Psyche 25: 4-12.

1918 A phylogenetic study of the terminal abdominal structures and genitalia of male Apterygota, Ephemerida, Odonata, Plecoptera, Neuroptera, Orthoptera, and their allies. Bull. Brooklyn Ent. Soc., 13: 49-68.

1920 Remarks on the basic plan of the terminal abdominal structures of the males of winged insects. Can. Ent., 52: 178-183.

1921 The sclerites of the head and the mouthparts of certain immature and adult insects. Ann. Ent. Soc. Amer., 14: 65-103.

1922 The genitalia of the males of certain Hemiptera (Heteroptera) and Homoptera. Bull. Brooklyn Ent. Soc., 17: 46-55.

1923 Preliminary note on the terminology applied to the parts of an insect leg. Can. Ent., 56: 126-132.

1925 External anatomy of head and abdomen of the roach, Periplaneta americana. Psyche 32: 195-219.

1928 The basal structures of the wings of certain insects. Bull. Brooklyn Ent. Soc., 23: 113-118.

Handlirsch, A.

1906 Fossilen Inseckten. Verlag von Wilhelm Engelmann, Leipzig, 48-49.

Hamilton, M. A.

1931 The morphology of the water scorpion, Nepa cinerea L. Proc. Zool. Soc. London, 1067-1136.

Heidemann, O.

1904 Remarks on the genitalia of Podisus cynicus Say and Podisus bracteatus Fitch. Proc. Ent. Soc. Wash., 7: 9-11.

Hoke, S.

1926 Preliminary paper on the wing-venation of the Hemiptera (Heteroptera).
Ann. Ent. Soc. Amer., 19: 13-35.

Holway, R. T.

1935 Preliminary note on the structure of the pretarsus and its possible phylogenetic significance.
Psyche 42: 1-24.

Howe, W. S.

1930 A study of the tarsal structures of Cicadellidae.
Ohio Jour. Sci., 30: 321-329.

Imms, A. D.

1935 A general textbook of entomology.
E. P. Dutton & Co., New York, 330-352.

Malouf, N. S. R.

1932 The skeletal motor mechanism of the thorax of the "stink bug" _Nezara viridula_.
Bull. Soc. Roy. Entom. d'Egypte, 161-203.

1933 Studies on the internal anatomy of the "stink bug," _Nezara viridula_.
Bull. Soc. Roy. Entom. d'Egypte, 96-119.

Marlatt, C. L.

1895 The Hemipterous mouth.
Proc. Ent. Soc. Wash., 3: 241-250.

Moody, D. L.

1930 The morphology of the repugnatory glands of _Anasa tristis_.
Ann. Ent. Soc. Amer., 23: 81-104.

Muir, F. and Kershaw, J. C.

1911 On the monologies and mechanism of the mouthparts of Hemiptera.
Psyche 18: 1-12.

1912 The development of the mouthparts in the Homoptera, with observations of the embryo of Siphanta.
Psyche 19: 77-89.

1925 On the status of the anterior processes of the male genitalia in Homoptera.
Proc. Hawaiian Ent. Soc., 6: 323-334.

Neiswander, C. R.

1926 On the anatomy of the head and thorax in Ranatra (Heteroptera).
Trans. Amer. Ent. Soc., 51: 311-320.

Parshley, H. M.

1915 Systematic papers on New England hemiptera.
II. Synopsis of the Pentatomidae.
Psyche 22: 170-178.

1923 Guide to the insects of Connecticut, Part 4: 758-773.

Pruthi, Hem Singh-

1925 The morphology of the male genitalia in Rhynchota.
Trans. Ent. Soc. London, 127-267.

Say, Thomas

1891 The complete writings of Thomas Say on the entomology of North America (The LeConte Edition).
A.F.Foote, Philadelphia, Pa. 312-313.

Sharp, David

1890 On the structure of the terminal segment in some male Hemiptera.
Trans. Ent. Soc. London, 399-427.

Smith, John B.

1892 The structure of the Hemipterous mouth.
Science 19: 198.

Snodgrass, R. E.

1921 The mouthparts of the Cicada.
Proc. Ent. Soc. Wash., 23: 1-15.

1929 The thoracic mechanism of the grasshopper, and its antecedents.
Smithsonian Misc. Coll. 82 (2): 1-108.

1930 How insects fly.
Smithsonian Rep. for 1929, 3050: 383-421.

1931 Evolution of the insect head and the organs of feeding.
Smithsonian Rep. for 1931, 3160: 443-489.

1931 Morphology of the insect abdomen, Part I.
Smithsonian Misc. Coll. 85: 1-125.

1933 Morphology of the insect abdomen, Part II.
Smithsonian Misc. Coll. 89: 1-148.

1935 Principles of insect morphology.
McGraw-Hill Book Co., Inc., New York.

Tanaka, C.

1926 Homologies of wing veins of Hemiptera.
Annot. Zool. Jap., Tokyo 2: 33-53.

Taylor, L. H.

1918 The thoracic sclerites of Hemiptera and Heteroptera.
Ann. Ent. Soc. Amer. 9: 225-250.

Tillyard, R. J.

1926 The insects of Australia and New Zealand.
Angus & Robertson, Ltd., Sidney, 114-145.

Tower, D. G.

1914 The mechanism of the mouthparts of the squash bug, <u>Anasa tristis</u> De Geer.
Psyche 21: 99-108.

Van Duzee, E. P.

1909 Synonymical and descriptive notes on North American Heteroptera.
Can. Ent., 41: 369-376.

Walker, E. M.

1919 The terminal abdominal structures of Orthopteroid insects: A phylogenetic study.
Ann. Ent. Soc. Amer., 7: 267-315.

## Abbreviations

A - anal opening
a - ventral lobe of seventh segment
aba - anterior basalare
aclp - anteclypeus
aed - aedeagus
anp - anterior notal wing process
ant - antenna
ao - anal opening
ap - apodeme
axc - axillary cord

bc - bulb of antennae
bgc - border of genital cup
bp - basal plate of aedeagus
bs - basisternum
bt - basitarsus
bu - bucculae

c - coxal cleft
cc - coxal cavities
cl - clavus
clp - postclypeus
cls - claval suture
cn - prothoracic-mesothoracic conjunctiva
co - corium
con - connexiva
cps - claspers of male genitalia
cr - collar-like rim of prothorax
Cu - cubitus
cv - convex ridge of prothorax
cx - coxa

dc - dorsal connectives of aedeagus
dt - distitarsus

e - compound eye
ed - ejaculatory duct
em - epimeron
emp - empodium
eps - episternum

f - fold of hind wing
fe - femur
fp - furcal pit
fr - frons
fre - frenum
fu - furca

ge - genae
gtp - genital plate
gu - gular region
gus - gular suture

hm - humeri
hp - humeral or basicostal plate

in - internal ridge connecting the tergum and pleuron of the prothorax
inr - inferior ridge of the male genitalia

k - transverse ridge between scutum and scutellum of mesothorax

lab - labium
lbr - labrum
lpl - lateral penial lobe

M - media
m - median groove
ms - muscle scar
md - mandibular setae
mem - membrane
mpl - median penial lobes
mx - maxillary setae

n - salivary duct

o - coxal articulation
oc - ocelli
occ - occipital arch
ocf - occipital foramen

p - food duct
par - parapsidial furrows
pba - posterior basalare
pclr- precostal ridge
pct - precosta
pem - parempodium
pf - prothoracic tergal flap
pge - postgenae
ph - phragma
pl - pleuron
pls - pleural suture
poc - postocciput
pos - postoccipital suture
pp - pleural wing process
prb - prealar bridge
prt - proctiger or rectal cauda
psc - prescutum
psl - postscutellum
ptar-pretarsus
pth - penial theca
pv - pulvillus

R - radius
r - ring "joint" of antenna
rd - ridge separating anterior basalare from the episternum
rg - ridge of mesothoracic basisternum

s - mandibular and maxillary setae
sa - scape
Sc - subcosta
sc - scutum
sct - scutellum
se - subalare
sg - scent gland
sp - spiracle
st - sternite

t - tergite
ti - tibia
tr - trochanter or fulcrum
trn - trochantin
ts - tarsus

un - ungue or claw
ut - unguitractor

va - vectis dorsalis anterior
vc - ventral connectives of aedeagus
vfl - valvifer
vl - valvula
vp - vectis dorsalis posterior
vs - ventral spine of third abdominal segment

x - axillary sclerite

## Explanation of Plates

Plate I

Fig. 1. Dorsal view of the head.

Fig. 2. Ventral view of the head, with labrum and labium detached.

Fig. 3. Cross section of the labium and basal segment of the labium to show the position of the setae.

Fig. 4. Ventro-lateral view of the head.

Fig. 5. Cross section of the maxillary and mandibular setae.

Fig. 6. Antenna.

Fig. 7. Cross section of the third labial segment to show the position of the setae.

Plate II

Fig. 8. Lateral view of the meso- and meta-thorax with the wings raised.

Fig. 9. View of the anterior portion of the mesothorax.

Fig. 10. View of the coxa to show the position of the trochantin.

Fig. 11. Fore leg.

Fig. 12. Fore wing.

Fig. 13. Hind wing.

Fig. 14. Dorsal view of the meso-metathorax and the base of the wings.

Fig. 15. Pretarsus of the fore leg.

Plate III

Fig. 16. Dorsal view of the prothorax.

Fig. 17. Ventral view of the prothorax.

Fig. 18. Ventral view of the mesothorax.

Fig. 19. Ventral view of the metathorax.

Fig. 20. Ventral view of female terminal abdominal segments showing the seventh sternal flap in normal position.

Fig. 21. Ventral view of female terminal abdominal segments showing the seventh sternal flap and the first valvifer raised.

Fig. 22. Caudal view of male terminal abdominal segments showing the proctiger in normal position over the genital region.

Fig. 23. Caudal view of male terminal abdominal segments showing the anus extended and the proctiger raised to allow a view of the aedeagus.

Plate IV

Fig. 24. Ventral view of the first three abdominal segments.

Fig. 25. Dorsal view of the female abdomen.

Fig. 26. Dorsal aspect of the aedeagus and its basal connections.

Fig. 27. Dorsal view of the extended eighth and ninth abdominal segments of the male.

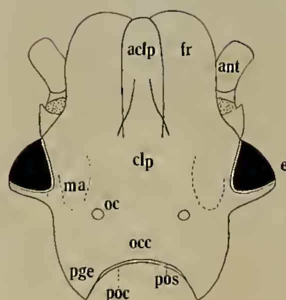


Fig. 1

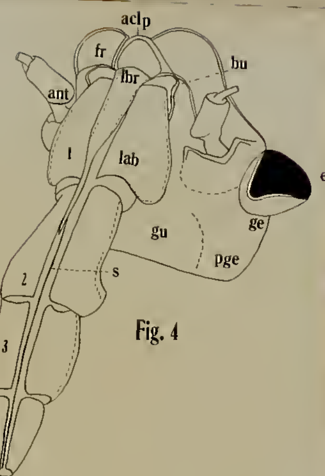


Fig. 4

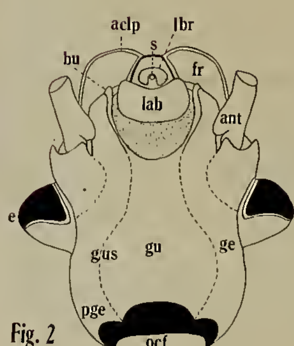


Fig. 2


Fig. 5

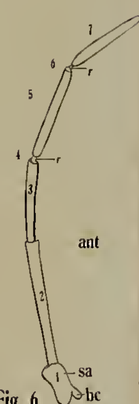


Fig. 6

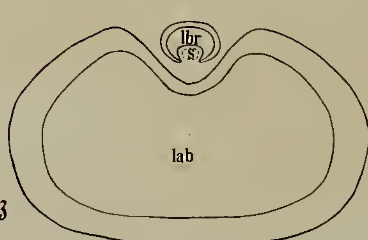


Fig. 3

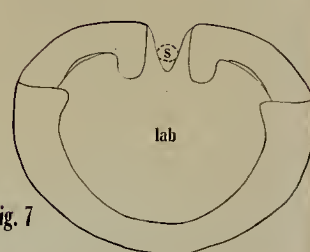


Fig. 7

PLATE I

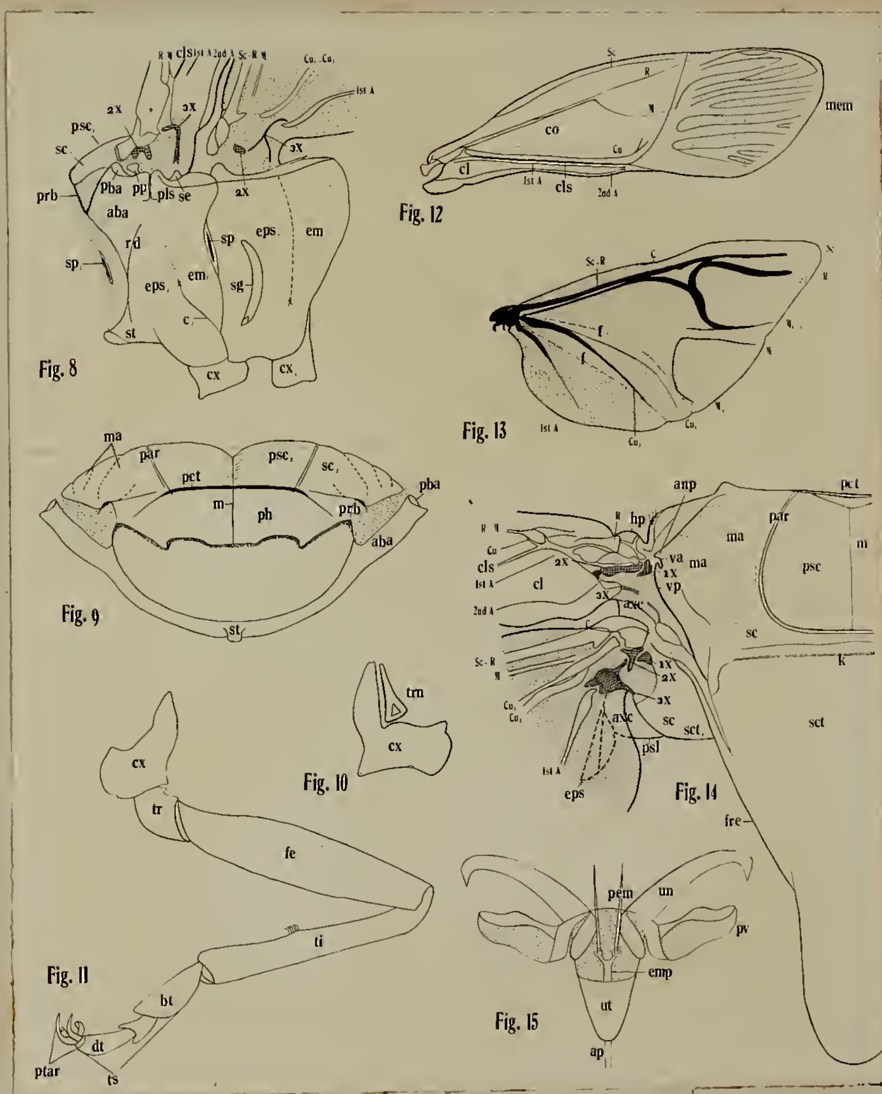


PLATE II

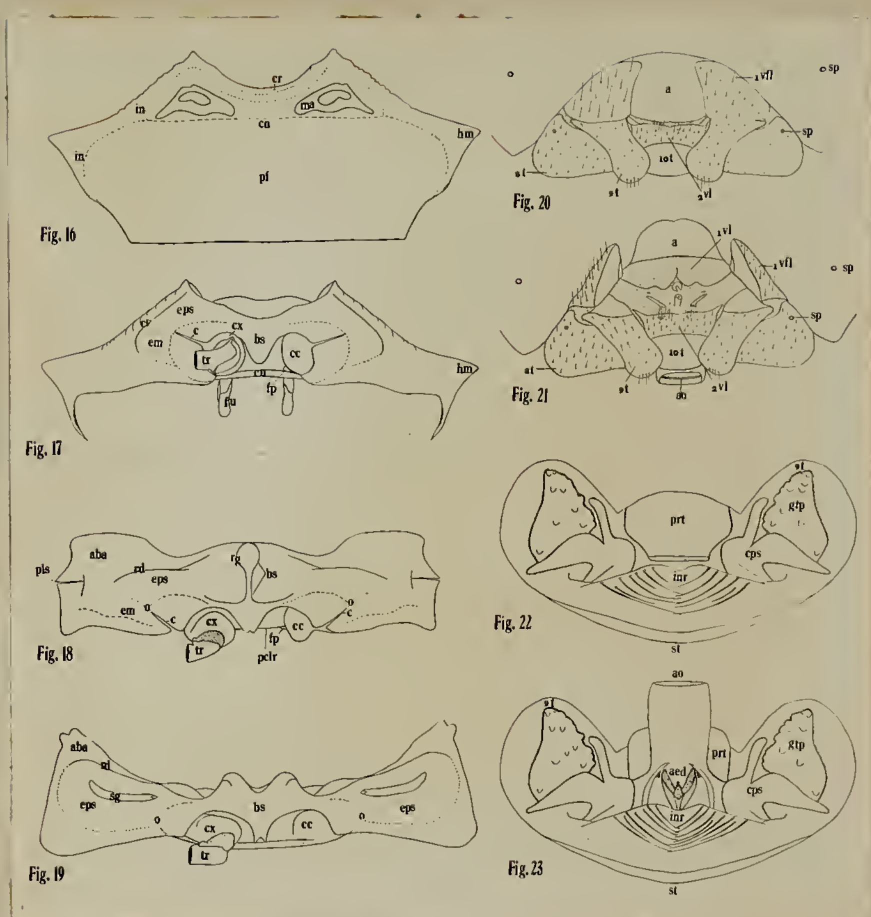


PLATE III

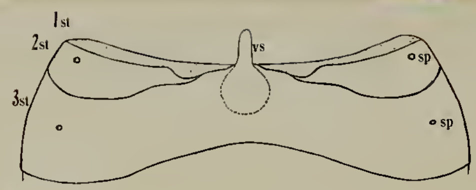

Fig. 24

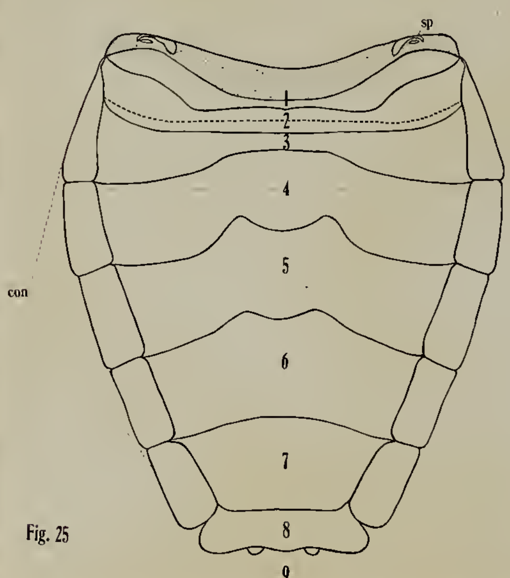

Fig. 25

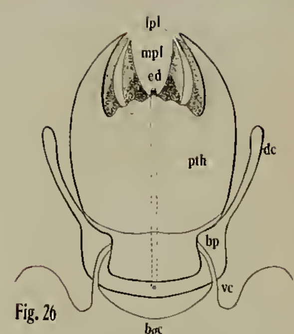

Fig. 26

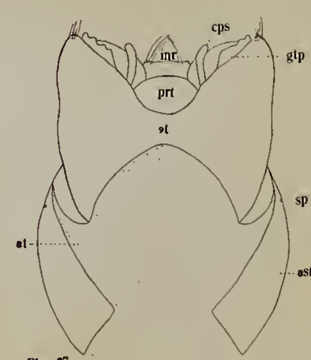

Fig. 27

PLATE IV

Approved by

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Graduate Committee

Date June 1, 1936